Utah Experience

With

Elastomeric and PPA Binder Modification

Local Solutions for Local Challenges

Utah has a unique climate and geography requiring unique solutions

Where is Utah?

Mountain
Basin and Range
Colorado Plateau
Low Desert
Great Salt Lake
Salt Lake City
West Valley City
Logan
Ogden
Roy
Layton
Bountiful
Murray
Morgan
Evanston
Woodruff
Randolph
Wendover
Tooele
Salt Lake Desert
Provo
Duchesne
Vernal
Nephi
Price
Mt Pleasant
Ephraim
Castle Dale
Gunnison
Delta
Fillmore
Richfield
Sevier Lake
Green River
UTAH
Moab
Junction
Panguitch
Beaver
Milford
Cedar City
Kanab
Page
Monticello
Blanding
Navajo Mtn
Malad City
Preston
Brigham City
Wheeler Pk

Climate

- Temperature Range
  - Low Desert: High 115^{o} F Low 26^{o} F
  - Colorado Plateau: High 110^{o} F Low -10^{o} F
  - Basin & Range: High 110^{o} F Low -15^{o} F
  - Mountain: High 100^{o} F Low -20^{o} F
- Common Daily Temperature Swing
  - Summer 40^{o} F
  - Spring/Fall 50^{o} F
  - Winter 30^{o} F

Traffic

- Local Industrial and Mining
- Cross Country Trucking
  - East/West I-80, I-84, I-70
  - North/South I-15, (666, 191, 6)

Challenges to Pavement

- Typical distress mechanisms
  - Rutting (hot)
  - Stripping (wet)
  - Fatigue Cracking (intermediate)
  - Thermal Cracking (cold)
  - Raveling (cold)
- Construction Flaws
  - Segregation (raveling)
  - Density (fatigue or raveling)

Observations

- Utah pavement performance history leads to the conclusion that mixes produced with refinery run binders will either rut or suffer brittle failure.
- Something must be added to the HMA mix to stabilize it in our climate extremes.
- Mixes built with the same binder but different aggregates perform differently.

Postulate

- Although binder is an important part of the stability of the mix, it is not the only important factor.
- Desirable mix properties can be extended by adding toughness to the binder.
- Desirable antistripping properties can be obtained through priming aggregate surfaces

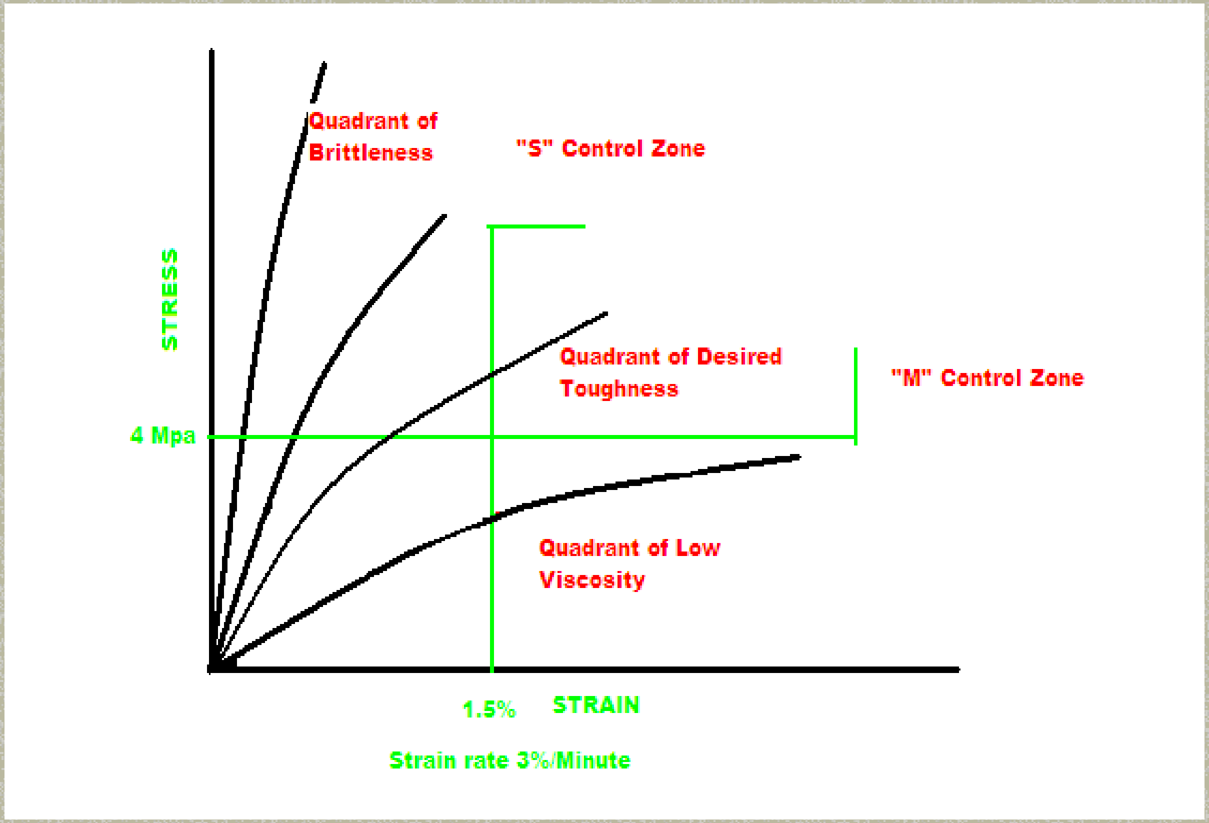
Specification Philosophy

- UDOT would rather support innovation through performance specification as opposed to recipe specification.
- Contractors and suppliers have great knowledge and must be included in development of specifications.
- Contractors and suppliers should control their own processes through quality control programs.
- Use Standard AASHTO tests with local interpretation.

Solutions

- Supporting cold temperature properties through toughness
- Supporting intermediate temperature properties through elasticity
- Supporting high temperature properties through high elastic stiffness
- Mix stability testing

Binder Toughness (Cold)

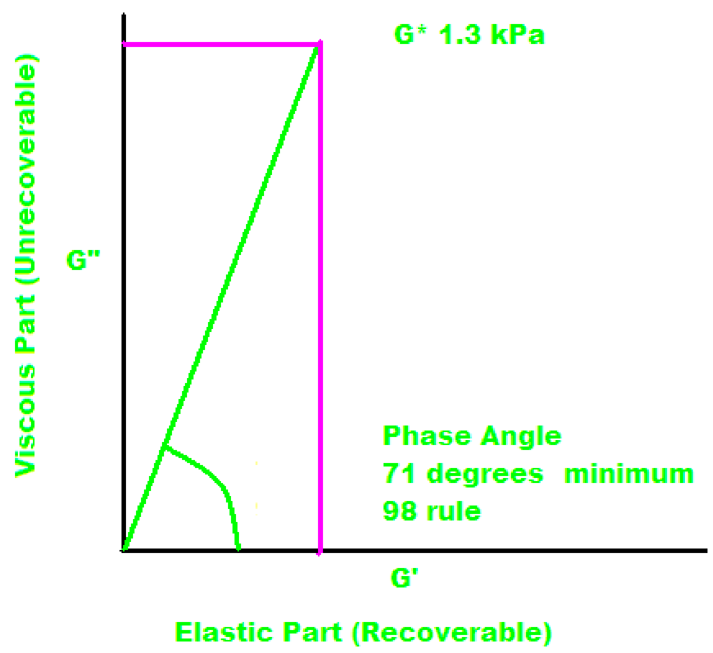


- Direct Tension at low grade temp.+10 deg. C, aged binder.

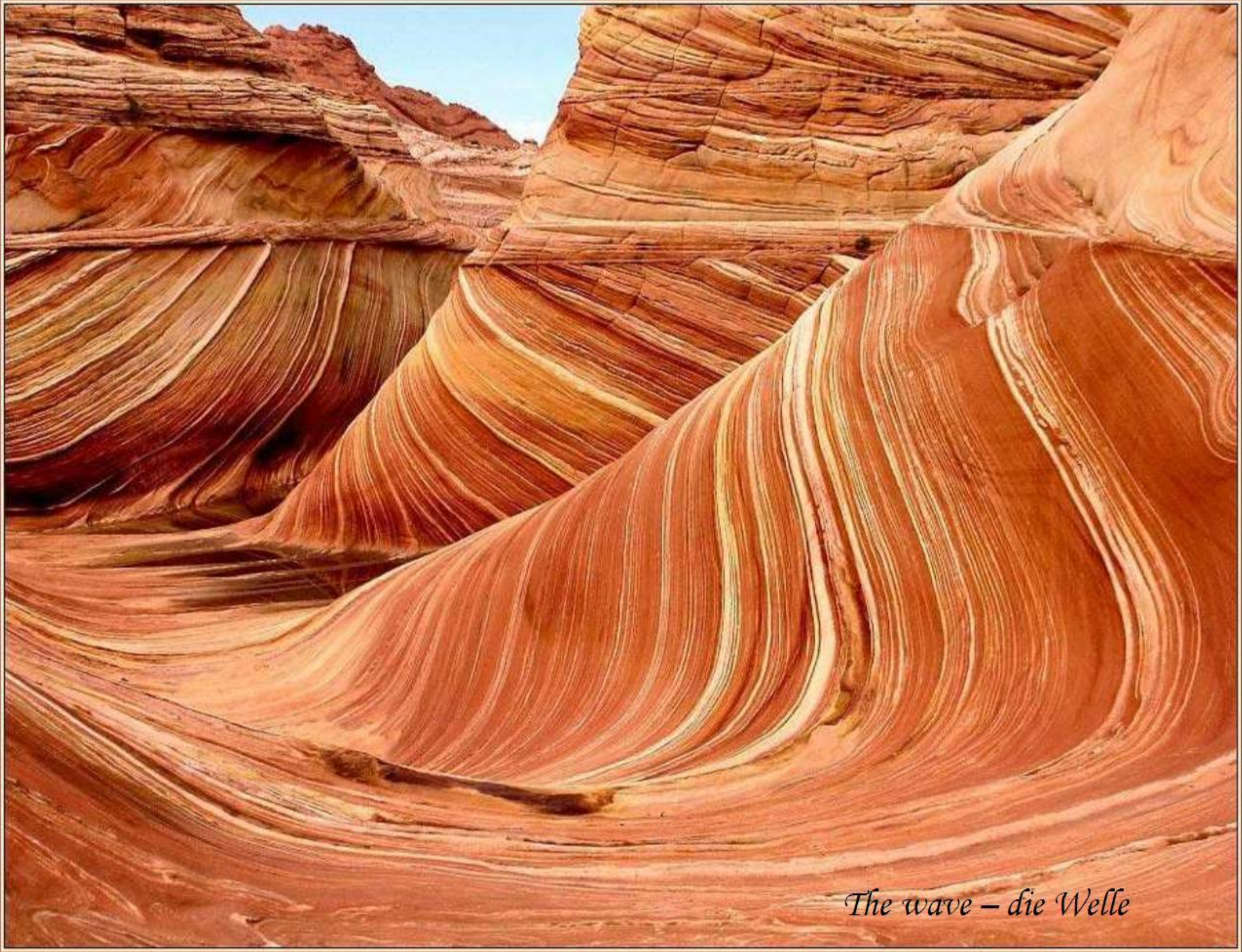
Elastic Recovery

- Test run at intermediate temperature, 77 deg F.
- Pull – Relax for 5 seconds – Cut
- Recovery must be 70% for Rule of 98
- Assures elastomeric properties in the standard fatigue temperature range.

Binder Elasticity (Hot)



- DSR at High Grade Temp. Unaged Binder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Mix Stability

- Hamburg Wheel Tracker
  - Drives High Temperature Stiffness
  - Drives Stripping Resistance
  - Drives post binder testing additives which may change the cold temperature toughness properties.
- Needed – Cold Temperature Mix Toughness Test.

Alternative Theory

- High Modulus for the MEPDG
  - I-84 Morgan 2005
    - Mill 8”, Till 8” and Cement Treat Base - 500 psi
    - 7” 64-34ut, TLA 4%, RAP 30%

Linear Kneading Compactor and Hamburg Wheel Tracker

Test Specifications

- 158 lb Steel Wheel load (203 mm Dia. by 47 mm wide)
- 20,000 passes per test
- Water Temperature @ 50° C (122° F), level and temp. maintained
- Speed @ 52 passes per minute
- Rut data recorded every 20 passes at 11 points using LVDT’s

Slab Preparation

- Compact to 7% air voids plus or minus 1%
- Slab size: 320 mm (12.6 inch) long by 260mm (10.2 inch) wide and 40 mm deep (1.6 inch).

Test Matrix

- Two Aggregates, Quartzite and Limestone
- Four Binders, two without acid and two with acid, all four are PG 64-34
- Each with and without Lime

Asphalt Binders: PG 64-34

These are off the shelf "branded" PMA binders

- Binder 1
- Binder 2
- Binder 3 – 0.85% Acid Modified
- Binder 4 – 0.56% Acid Modified

Gas Chromatography is the method used to measure the acid content. It looks for the approximate phosphorus amount.

Unknown Information

- Base Binder
- Binder formulation
- Polymer and Acid data

Aggregates

- Crushed Quartzite
- Crushed Limestone

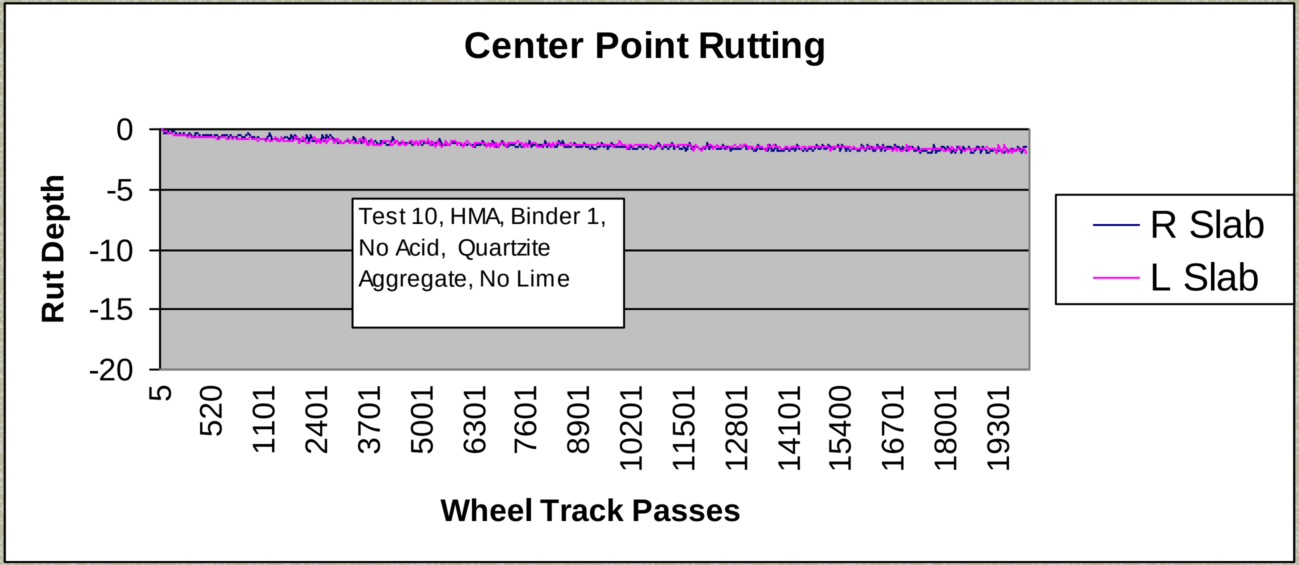
Quartzite and Limestone Aggregate Physical Properties

Table 1. Quartzite and Limestone Aggregate Physical Properties			
Test Method	**Quartzite**	**Limestone**	**UDOT Spec.**
Soundness AASTHO T-104 (Sodium Sulfate)	2.09	10.07	16% Max
Natural Sand	0	0	0% Max
Fracture Face Count - One Face	100	100	95% Min
Fracture Face Count - Two Face's	97	95	90%Min
Los Angeles Wear, AASHTO T-96	16.9	24	35% Max
Sand Equivalent, AASHTO T-176	71	69	60% Min
Uncompacted Voids, AASHTO T-304	46.5	46	45% Min
Flat and Elongated (1:3) ASTM D-4791	7.2	10	20% Max
Dust Ratio, SP-2	1	1	0.6 - 1.4
Plastic Index, ASTM D-4318	NP	NP	0% Max

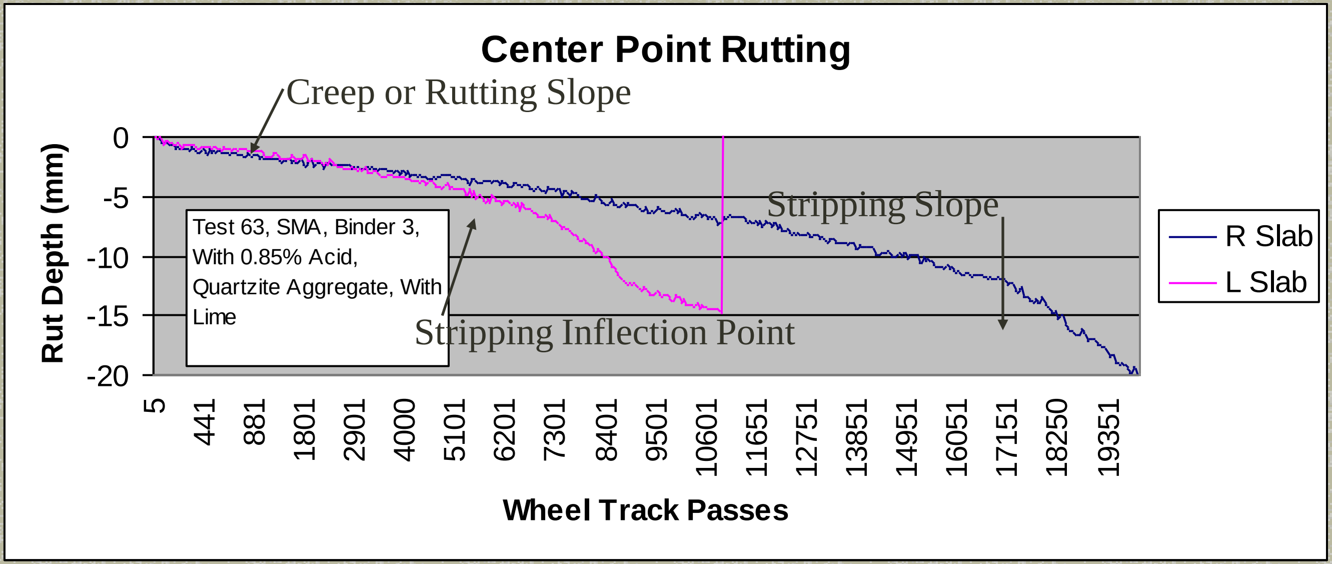
Hamburg Test in Operation

Example Hamburg Slabs

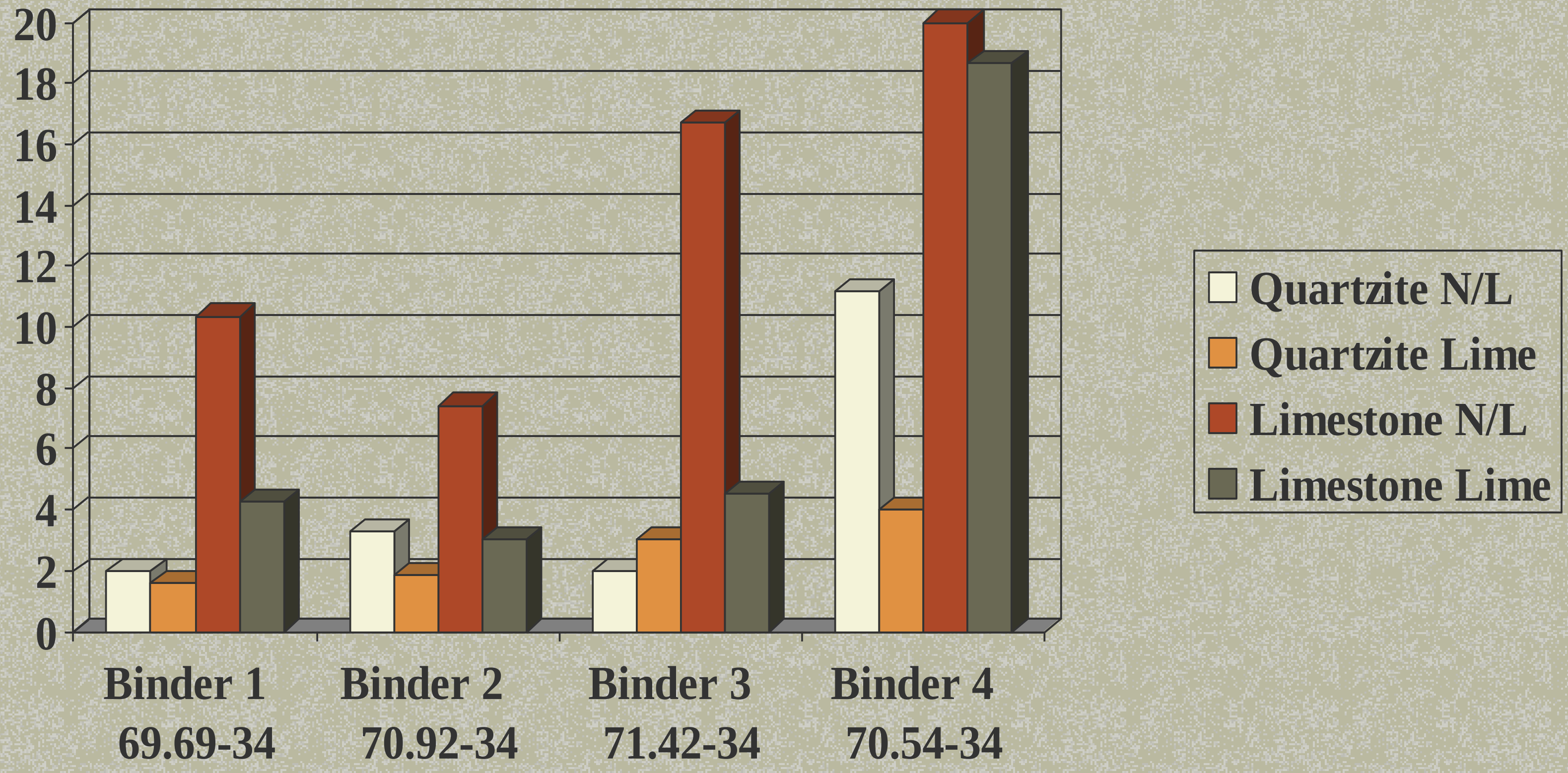
Example Test Graph
Passing Test



Example Test Graph
Failing Test

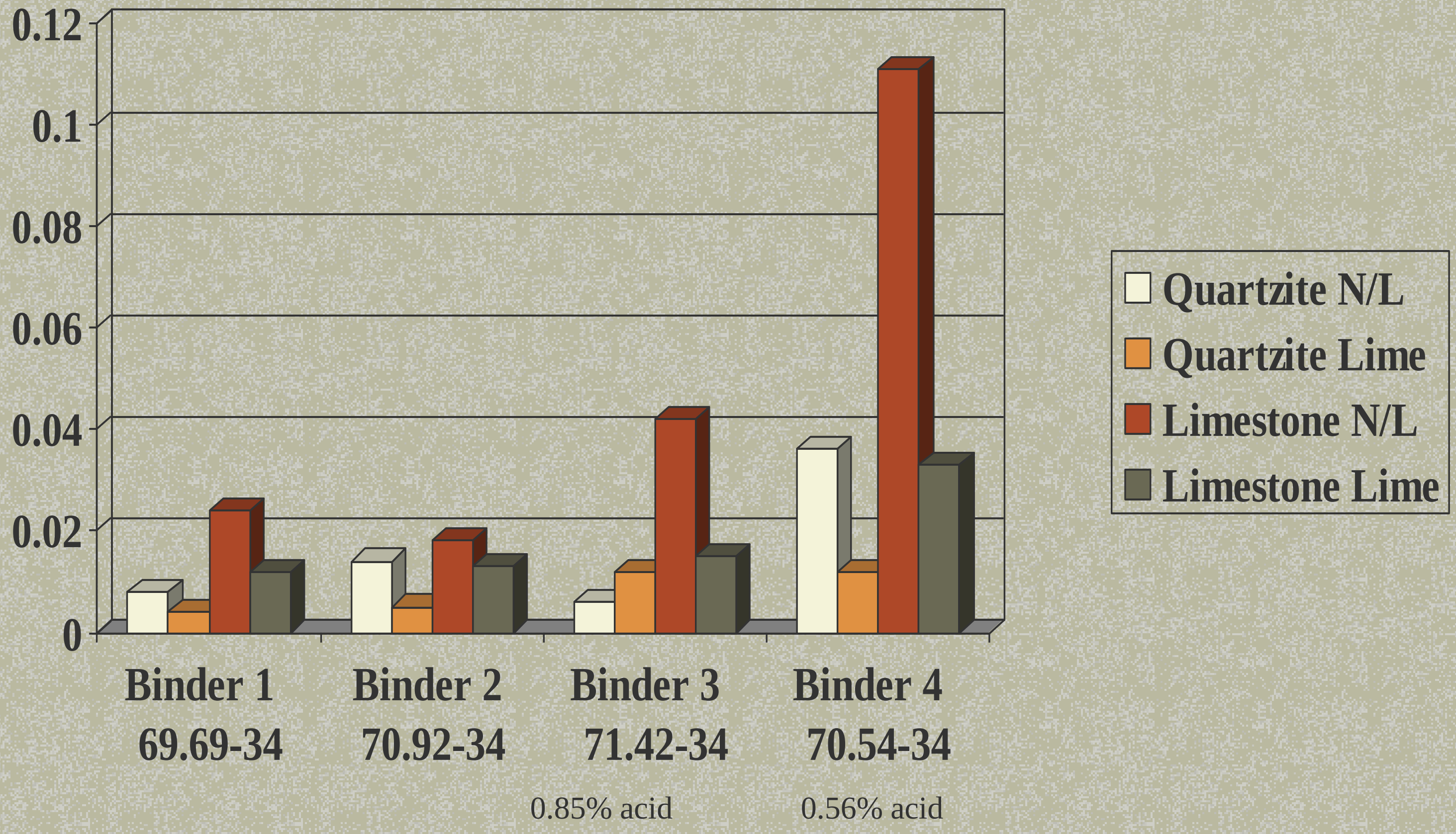


HMA Maximum Rut Depth (mm)

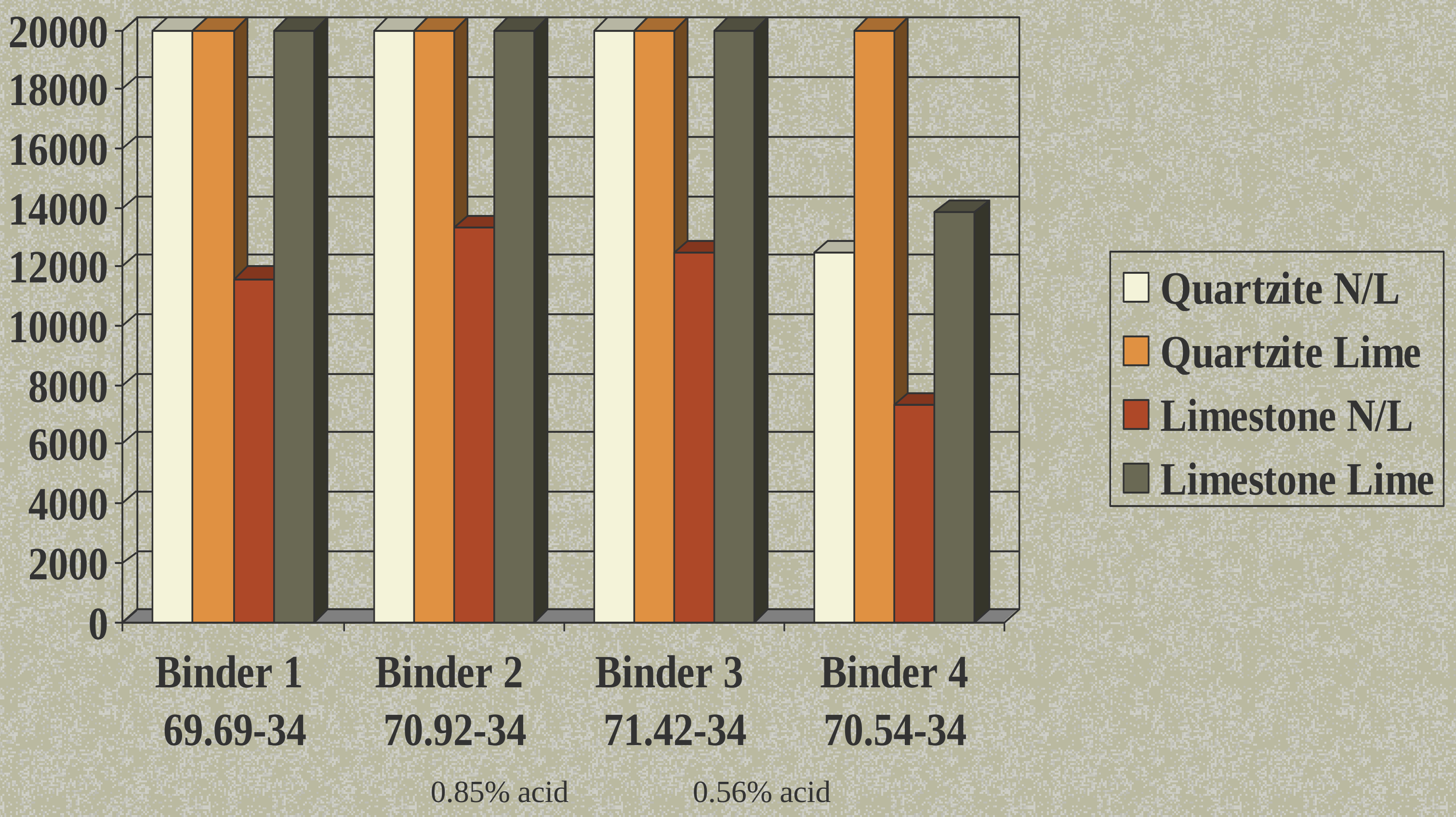


0.85% acid 0.56% acid

HMA Rut Slope (percentage)



HMA Average Inflection Point (Passes)



Conclusions

- Acid modification may or may not help the mix. How much depends on compatibility issues.
- These results point out the need for mix testing.
- Hydrated Lime reduces the rutting slope by about half.
- Presence of inflection point is not desireable.

Recommendations

- Always check the mix for performance with the Hamburg – We need Mix Tests!
- Follow exact procedures in preparing Hamburg samples and running the test.
- To test for acid and other formulation parts, we need more than the AASHTO M-320 specification. This leads to local plus specifications.